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Neuro-Cognitive Assessment, Symptoms of Attention Deficit and Hyperactivity Disorder, and Soldier Performance during 68W Advanced Individual Training

by Valerie J. Rice, Diane Marra, and Jenny Butler

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Neuro-Cognitive Assessment, Symptoms of Attention Deficit and Hyperactivity Disorder, and Soldier Performance during 68W Advanced Individual Training

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14. ABSTRACT

This study is one in a series of studies examining factors that impact Soldier performance during Advanced Initial Training (AIT). This study examines the relationships between a) Soldier performance using the Interactive Metronome[1] (IM), a new interactive computer technology used to assess neuro-cognitive function in terms of auditory and visual input with psycho-motor timing and rhythm output, b) symptoms of attention deficit and hyperactivity disorder (SoAD/HD), and c) academic and physical performance during military occupational specialty 68W AIT. Pearson product correlations and backward stepwise regressions were used to analyze the data. Participants included 122 Soldiers attending 68W AIT. Results revealed a negative correlation between SoAD/HD and grade point average (GPA) ($p = 0.03$). Results also revealed correlations between overall ($p = 0.03$) and inattentive type ($p = 0.00$) SoAD/HD and IM performance without auditory cues hypo-anticipatory scores (the individual is late in his response) ($p < 0.05$). In addition, the IM assessment with auditory cues was predictive of AIT performance including GPA and all components of the Army Physical Fitness Test and of both the total number of new musculoskeletal injury (MSI) profiles and total profile days for MSIs. Although the R-square was small in each case ($R^2 \leq 0.13$), these results demonstrate relationships between neuro-cognitive performance as measured by the IM, SoAD/HD, and physical and cognitive performance during AIT. Additional research is recommended on SoAD/HD among Soldiers, training with the IM to reduce attrition and improve cognitive performance among Soldiers at risk for reduced performance during AIT, and the use of IM training to improve physical performance and reduce MSI injuries.

[1]Interactive Metronome is a registered trademark of Interactive Metronome.

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brain training; cognitive performance; psychomotor performance

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1. Introduction

This research is part of a series of studies designed to examine factors that impact Soldier performance during military occupational specialty (MOS) 68W, Health Care Specialist, Advanced Initial Training (AIT). Specifically, this report is part of a larger project identifying predictors of academic and physical performance in order to design individualized intervention tools to help Soldiers improve their performance while attending AIT[1]. The portion of the project described in this report examines the relationships between (a) Soldier performance using the Interactive Metronome[2] (IM), a new interactive computer technology used to assess neuro cognitive function in terms of auditory and visual input with psycho-motor timing and rhythm output, (b) symptoms of attention deficit and hyperactivity disorder (SoAD/HD)[3], and (c) academic and physical performance during MOS 68W AIT.

2. Background

2.1   MOS 68W Health Care Specialist AIT

The Health Care Specialist Program, MOS 68W, is designed

> To prepare enlisted personnel to become Soldier medics and (to) provide emergency medical treatment, limited primary care, force health protection and evacuation in a variety of operational and clinical settings from point of injury or illness through the continuum of military health care. The trainee receives specific training in combat and military operations other-than-war casualty care, medical care for patients exposed to weapons of mass destruction, deployable medical systems, aircraft and ground evacuation, and casualty triage and processing. The course trains the requirements of the National Registry certified as an EMT-B. (Courtesy of the U.S. Army Medical Department Center & School [AMEDDC&S] 68W web site.) See figure 1.

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[1]The full research proposal is available upon request.

[2]Interactive Metronome is a registered trademark of Interactive Metronome.

[3]In this report, the term Symptoms of Attention Deficit and Hyperactivity Disorder (SoAD/HD) is used to refer to symptoms of both Attention Deficit Disorder (ADD) and Attention Deficit and Hyperactivity Disorder (ADHD). When distinctions are made, they are clearly identified by type: inattentive or hyperactive-impulsive. A third grouping of symptoms for oppositional defiant disorder (ODD) is also clearly identified, as is the grouping for an overall score for SoAD/HD.

Figure 1. Health care specialist (courtesy of AMEDDC&S
68W web site).

To prepare Soldiers for the requirements of being a 68W Health Care Specialist, the Army pro-
vides an 16-week training program at the AMEDDC&S, Department of Combat Medic Training,
at Fort Sam Houston, Texas. Young service men and women typically attend this immediately
after completing basic combat training (BCT). The first seven weeks of training involve cardio-
pulmonary resuscitation and emergency medical training, followed by nine weeks of classroom
lecture, interactive computer training, and life-sized patient simulation, to develop the core skills
required for combat casualty care. Becoming nationally certified as emergency medical
technicians is part of the course requirements. It is an intense training program.

It is also a critical shortage MOS. There is an increased need for 68Ws since the beginning of
Operation Iraqi Freedom and Operation Enduring Freedom. Recruiting efforts do not adequately
bridge the gap between those needed and those entering training. In light of the current demands,
the failure and recycle rates (attrition) for Soldiers attending the intensive 16-week 68W AIT
program are unacceptably high[4].

The Health care Specialist Program has one of the five highest attrition rates among health care
training programs. The fiscal year (FY) 2005 attrition rate for all those attending is 18% and 21%
for active duty Army Soldiers (figure 2). These data only include "new starts," that is, those who
are new to the program. Each person attending is permitted to fail and recycle back into another
68W training class one time. For those who have failed once and have recycled back into the
class, the passing rate is 56%, with a class range from 17% to 59% (Hansen, 2006).

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[4]Other academically demanding AIT programs are also experiencing high rates of academic attrition (recycles or
reassignments). MOS examples include explosive ordnance disposal, respiratory care specialists, and medical
equipment repair specialists. One Navy example is aviation electronics repair.
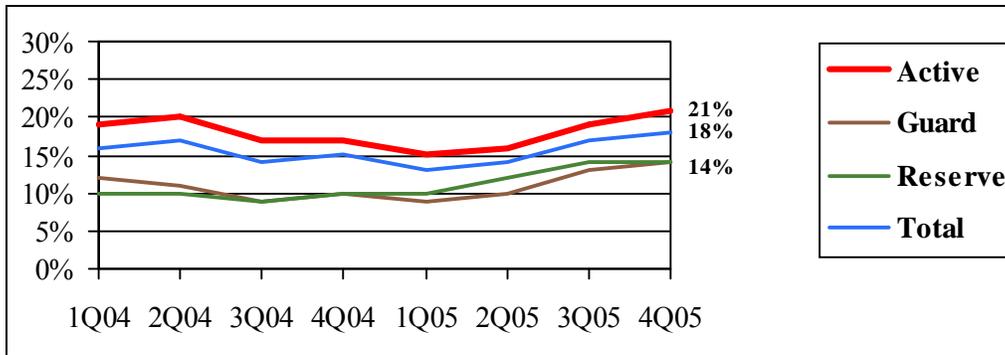
Figure 2. FY 2005 attrition among 68W trainees (Hansen, 2006).

Each time a Soldier fails to complete AIT, it costs the Army directly in terms of manpower and resources. Financial expenditures include Soldiers' travel, housing, and subsistence, as well as funding for instructors, materials, and training. The cost of failure to the Soldier and his or her family is time, energy, and often the Soldier's morale. Hidden costs occur when too few health care specialists are available to provide medical treatment to their fellow Soldiers and their families.

Approximately 1,080 Soldiers recycle to a new MOS from 68W AIT each year. Assuming that a Soldier makes it one-fourth of the way through the 16-week 68W AIT program on each of the two permitted trials before recycling to a new MOS, the cost to the Army is approximately $2,500,000 annually—money spent on those Soldiers who fail and must attain another MOS (not including travel, housing, and retraining at another military installation)[5].

2.2   Symptoms of Attention Deficit and Hyperactivity Disorder (SoAD/HD)

Potential reasons for Soldiers having difficulty with the academic demands of the 68W program were identified during a series of focus groups with drill sergeants, academic instructors, company commanders and administrative staff. Included among the behaviors described were difficulties in the ability to concentrate, to focus attention during class, to complete projects, and to organize time and activities. Supervisors and instructors reported observing Soldiers who seemed easily distracted and had difficulty "being still" (Rice, Woods & Bundy, unpublished data). Although these behaviors could be attributable to other reasons, they are also associated with attention deficit and hyperactivity disorder (table 1) (AD/HD).

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[5]With the equation: 6,000 x 0.18 x 0.44 x $5,100 = COST, where 6,000 = the approximate number of Soldiers entering 68W training each year, 0.18 = current 18% attrition rate, 0.44 = current failure rate of those recycling back into training, $5,100 are derived from the approximately $19,200 spent on a trainee during AIT. One-fourth of that equals $5,100. This does not include travel, housing and retraining at another post. It does not include approximately $27,619 that has already been spent on recruiting, processing through the military entrance processing station, and basic combat training.

Table 1. Symptoms of attention deficit and hyperactivity disorder.

• Inattention; difficulty paying attention; excessive distractibility
• Hyperactivity; physical restlessness; difficulty being still
• Impulsivity
• Lack of focus
• Excessive and chronic procrastination
• Difficulty getting started on tasks
• Difficulty completing tasks
• Frequently losing things
• Disorganization
• Poor planning and time management
• Excessive forgetfulness

AD/HD is considered a disorder of attention. Individuals with AD/HD have historically been labeled as under-achievers and as having difficulties in school and at work. The symptoms associated with AD/HD (SoAD/HD) can interfere with academic performance (Barkley & Murphy, 1998; Heiligenstein, Guenther, Levy, Savino, & Fulwiler, 1999; Spinella & Miley, 2003). For example, youth with SoAD/HD have more grade retention, lower class rankings, and lower grade point averages (GPA) (Barkley & Murphy, 1998). However, recent publications have emphasized that AD/HD affects individuals in different ways and that it may be more advantageous to view AD/HD as a "style of working and thinking that presents both negative attributes and positive qualities" (Grossberg, 2005, p 4). In fact, recent writings emphasize that those with AD/HD can learn to use some of their unique ways of viewing the world and their attributes to benefit themselves and their employers (Grossberg, 2005; Hallowell & Ratey, 2006).

Under current Army doctrine, individuals with AD/HD are eligible for active duty if they demonstrate passing academic performance (high school or general equivalency diploma [GED]) and have not taken medication for AD/HD for a year before they enter the service (National Research Council, 2006). Although there is little research on AD/HD or the SoAD/HD among the active duty population, it has been shown that individuals with a history of AD/HD graduate BCT at the same rate as those without such a history (Accession Medical Standards Analysis & Research Activity, 2002). Ross (1997) predicted a significant portion of a Marine's performance on the Marine Corps measure of performance based on a number of measures of attention deficit disorder: high attention deficit symptoms resulted in low stress tolerance, as well as poor performance in military training. Among 530 Soldiers attending 68W AIT, approximately 30% scored above the adult norms on Barkley and Murphy's (1998) AD/HD scales, which indicates the presence of symptoms of AD/HD (Rice, Butler, and Marra, unpublished data).

2.3 Interactive Metronome

The IM is an interactive computer technology designed to help individuals develop their internal sense of timing and rhythm. While simple practice of rhythmic movements may improve an individual's timing and rhythm, it is also thought that training particular areas of the brain can strengthen those neural networks. This "strengthening" would then generalize to other tasks that use those same neural networks in much the same way that strengthening a person's arms will improve his or her ability to lift, row, and carry.

Timing and rhythm underlie other more complex tasks (Lam, 2002; Shaffer, Jacokes, Cassily, Greenspan, Tuchman, & Stemmer, 2001). For example, an even rhythm of eye movement (saccadic rhythm) is essential for reading, and a rhythmic pattern of body and limb movement make it easier to participate in a run around a track. The IM delivers auditory (and to a lesser extent, visual) input to an individual, and the individual responds with precise psychomotor output in an attempt to match the auditory beat (figure 3). Accuracy is measured in milliseconds.

Figure 3. Soldiers performing hand motions during IM assessment.

The IM is used clinically to help individuals improve their focus (ability to pay attention, concentration) and motor control (planning, sequencing, coordination). It is used to improve information processing and psychomotor timing, as well as to lessen SoAD/HD in children diagnosed with AD/HD (Shaffer et al., 2001). It has also has been shown to achieve functional improvements in academic (math, reading, information processing speed), behavioral (reducing SoAD/HD), and physical (sports) performance (Kuhlman & Schweinhart, 1999; Mulder, 2002) in a variety of student populations with and without any clinical diagnoses. Major sports teams and individuals, such as the Miami Dolphins, the Miami Heat, VeeJay Singh, and athletes attending Notre Dame also use the IM to improve their timing and performance (Interactive Metronome, 2006).

The theoretical basis for IM training is as follows:

1. Higher level processes, such as organizing and sequencing, depend on an internal sense of timing and rhythm.

2. Exercise of regions of the brain can strengthen the neural networks within those regions, thus leading to improvements in brain function which generalize to other tasks performed by that neural network.

This training also requires an individual to focus attention (both auditory and visual) on a specific task. Each training session slowly increases the time required for a task, thus giving the person feedback (auditory and visual) about accuracy which is only maintained through attentiveness. That is, negative feedback is also given each time the person's attention wanes. This sequentially increases an individual's ability to focus attention over time.

The areas of the brain activated during IM use include the pre-frontal region, the cingulated gyrus, basal ganglia, and the medial brain stem. The pre-frontal region of the brain is responsible for *planning, sequencing, analysis, decision making, and high-order motor control*. The cingulate gyrus allows *shifting of attention*, the basal ganglia *integrates thought and movement*, and the medial brain stem is involved in *neuro-motor control* (Guerra, 2006). Therefore, in theory, specific exercise of those portions of the brain could improve the functions associated with those areas.

It is now known that brain activity can be influenced and improved throughout the life span, that is, a certain level of plasticity remains. It has also been shown that neural networks can be strengthened, and training certain areas of the brain results in generalized improvements when that portion of the brain is used for other tasks (Posner, 2006).

A study conducted at the Naval Aerospace Medical Research Laboratory compared pre- and post-training IM scores by enlisted students on cognitive performance and neural efficiency, as evidenced by factors such as auditory sequencing performance, psychomotor skills, problem solving, visual sequencing, decoding, and divided attention. Although all students did not achieve significant improvement, the researchers found that students with the lowest Armed Services Vocational Aptitude Battery (ASVAB) scores showed significant improvements in the area of visual association memory after 10 sessions of training. Since the greatest achievements were sustained by those individuals with the lowest initial scores, they concluded that students with the lowest aptitudes (those at greatest risk) may benefit most from IM training (Fatolitis, Ekenna-Kalu, & Momen, unpublished).

3. Purpose

In order to graduate from AIT, Soldiers must achieve passing scores on their academic class work, skills tests, and the Army Physical Fitness Test. Required underlying capabilities (among others) include the ability to concentrate and focus attention, to organize and prioritize, and to perform complex motor skills. Since IM training has been found to improve academic and physical performance (for those with and without disabilities) and to assist in improving attention among youth with AD/HD, it was felt that similar training might assist Soldiers attending demanding AIT. However, since no research has examined IM performance among young adults, more information was necessary before such a training effort was initiated. Therefore, the focus of this research effort was to identify the presence or absence of SoAD/HD among a population of Soldiers attending 68W AIT and to examine the relationship between SoAD/HD, scores on the IM screening assessment, and AIT performance (GPA and physical fitness).

4. Methods

All participants were Soldiers in the 232nd Medical Brigade, C Company, attending 68W AIT. Since this study was a subsidiary of a larger study, all participants read and completed a consent form for entire study before their participation. The consent form included information about this portion of the study, specifically describing IM testing.

A random sample of 68W Soldiers (n = 108) who volunteered for all portions of the study were selected for IM testing. Although a sufficient *n* was obtained for the IM portion of the study, 15 additional Soldiers who were part of the overall study and had scores above the adult norm on Barkley and Murphy's Attention Deficit and Hyperactivity Scale[6] were invited to perform the IM testing (see section 4.1.2 for a description of this scale). These Soldiers were invited to join the IM sample in order to match the 30% incidence of higher–than-adult-norm SoAD/HD occurring in the larger study population (n = 560). The final number of soldiers who completed this study was n = 107+15 = 122.

Participants completed two self-assessment questionnaires during the first two weeks of the 68W course, which included information about demographics and SoAD/HD. IM testing occurred approximately 5 weeks into the course during time normally dedicated to physical training. Each Soldier spent approximately 2 hours participating in the evaluations, 1 hour for the questionnaire and 1 hour for the IM evaluation.

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[6]An individual who scores above the adult norm has more symptoms associated with AD/HD than the "average" adult.

Participating Soldiers' GPA, physical fitness scores, and information about musculoskeletal injuries were obtained from unit records upon completion of the course. Only two Soldiers participating in this study failed the course.

4.1 Self-Assessment Questionnaires

4.1.1 General Information Questionnaire

This self-report questionnaire includes demographic and general information. It contains gender, age, marital status, race, military component, level of education, overall high school GPA, and GPA for high-school science courses. All responses were by self-report.

4.1.2 Barkley and Murphy's Attention Deficit and Hyperactivity (AD/HD) Scale

Barkley and Murphy's (1998) AD/HD scales are used to measure SoAD/HD among adult populations by a compilation of self-rating checklists to determine the existence, prevalence, and impact of AD/HD symptoms. The questions are derived from the Diagnostic and Statistical Manual of Mental Disorder 4th Edition(DSM-IV) (American Psychiatric Association, 2000) and include questions to assess the individual's ability to focus attention, concentrate, and control impulsivity. The results fall into four categories: overall SoAD/HD, hyperactive/impulsivity, inattention, and oppositional defiant disorder (ODD) (see table 2). Although these rating scales cannot take the place of a professional diagnosis by a clinician, together with the performance data, they can provide us with an indicator of whether Soldiers with these symptoms are having difficulty with course demands.

Table 2. Symptoms within each category associated with Barkley & Murphy's attention deficit and hyperactivity scale.

Hyperactive/impulsivity	Inattentive	Oppositional Defiant Disorder
In children, they must exhibit four of the following symptoms for at least six months.	In children, they must demonstrate six of the following symptoms for six months.	In children, they must show at least four of the symptoms for six months.
- Often figets or squirms. - Leaves his seat in the classroom or in other situations in which remaining seated is expected. - Often runs about or climbs in situations when it is inappropriate. - Often has difficulty playing quietly. - Often blurts out answers before the whole question has been stated. - Often has difficulty waiting in lines or awaiting his turn in group play.	- Often fails to give close attention to details or makes careless mistakes in schoolwork or other activities. - Often has trouble sustaining attention in tasks or play. - Often doesn't seem to listen to what's being said to him. - Often doesn't follow through on instructions and fails to finish schoolwork or chores (not out of rebellion or failure to understand). - Often has difficulty organizing tasks and other activities. - Avoids or strongly dislikes tasks (such as schoolwork or homework) that require sustained mental effort - Often loses things necessary for tasks or activities (such as toys, school assignments, pencils, and books). - Is often forgetful.	- Often loses tempter or has frequent temper tantrums - Argues excessively with adults, active defiance - Often refuses to comply with requests or follow rules. - Deliberately attempts to annoy or upset people - Blames others for their own misbehavior and mistakes. "Touchy" or easily annoyed by others. - Often angry and resentful - Often spiteful, vindictive or seeking revenge.

For diagnosis among children, these symptoms typically occur by age 7, take place in more than one place, disrupt social interactions or academic performance, are on-going, and are greater than those among other children of the same age. Symptoms among adults can differ, displaying more often as inattention, rather than fidgeting, squirming etc.

4.2   Interactive Metronome

As mentioned previously (section 2.3), the IM is used to assess and train individuals on timing (temporal tracking) and rhythm tasks in order to improve brain function. Specifically, training with the IM is advertised as helping individuals improve concentration, ability to focus attention, process information, control aggression and impulsivity, as well as improve basic motor planning, sequencing capabilities, and coordination. In addition, it is used to improve academic performance (math and reading fluency) and decrease the SoAD/HD (www.interactivemetronome.com).

The technology consists of headphones, hand and foot triggers, and IM Pro 8.0 software, and a small hardware controller box, connected to a personal computer. This assessment of temporal tracking ability requires individuals to maintain synchrony with auditory tones (e.g., from a metronome) while tapping a device with their hands, feet, or hands and feet together in various patterns. Each participant wears a small fabric cuff with built-in sensor slipped over one hand for clapping input or taps a foot pad with an embedded sensor. Scores are based on the individual's ability to minimize the latency between the onset of the computer-generated metronome sound and their ability to match the cue with action (tapping of the sensors). Scores are measured in milli-seconds (ms) with a resolution of 15 ms. Available research has reported performance changes measured over time, with IM as a training tool; however, a single assessment session was used for this research. Participants attempted to match the reference tones during two hand-clapping tasks, one without and one with auditory feedback cues, hereafter referred to as without cues (without C) and with cues (with C). During training, these sounds help the participant by providing feedback in the form of guide sounds that indicate by pitch if each clap is on target, early, very early, late, or very late. However, during initial testing and training, auditory cues are distracting, thus providing information about how well participants can do the task with and without auditory distractions.

Figure 4. Soldiers performing upper extremity clapping timing task with the IM.[7]

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[7]Although it is possible that Soldiers can be distracted when they are tested side by side, as in figure 4, testing and training are typically conducted in this manner when the IM is used for large groups of students or athletes. When evaluating or treating a patient, most clinicians use a more private setting to prevent distractions.

Researchers first demonstrated the task and then had participants demonstrate their ability to do the task. Upon acceptance of their demonstration by the researcher, the participants began the screening task. Table 3 contains terms and definitions used in the IM software sub-score categories.

Table 3. IM terms and definitions.

IM Term	Definition
Task Average	The millisecond (ms) average indicating how close the individual's hits were to the reference tone during a task. ***The lower the number, the better the performance.***
Variability average	This is a measure of how close the trigger hits were to each other, instead of to the reference beat.
No. of Bursts	"Bursts" refers to the number of times four hits in a row (IAR) was achieved within the "super-right-on" (SRO) time window.
Highest in a row (IAR)	Refers to the highest number of SRO trigger taps in-a-row were recorded in a particular task.
Very early average (in ms)	An average from trigger hits recorded 100 ms or greater, in anticipation of or "very early" prior to the reference tone.
Early average (in ms)	Displays scores from trigger hits that recorded early, but within 100 ms of the reference tone.
SRO% = "Super-Right-On" %	Indicates the percentage of taps recorded that were within ($\pm$) 15 ms of the reference tone.
Late average (in ms)	Displays scores from trigger hits that recorded after, but within 100 ms of the reference tone.

The IM assessment consisted of an initial short-form test, a long-form test, and a repeat of the short-form test. The short-form test consists of a two-handed (upper extremity) clapping task, first completed without auditory feedback and then completed with auditory feedback. The long-form test consists of 13 tasks that require the use of upper and lower extremities in various combinations (such as right hand/left foot, both toes, both heels, etc.). The entire evaluation takes approximately 45 minutes. In an effort to use the IM testing as a more abbreviated screening tool, only the data from the initial short-form test were analyzed for this report[8].

4.3 AIT Performance Measures

4.3.1 Grade Point Average (GPA)

Final GPAs were obtained through the Chief of Academic Standards and compared with scores from the IM timing assessments, SoAD/HD rating scales, and APFT results.

4.3.2 Army Physical Fitness Test (APFT) Scores

The APFT is comprised of the maximum number of sit-ups completed in 2 minutes, maximum number of push-ups completed in 2 minutes, and a timed 2-mile run. Raw scores from the first APFT, taken during the third week of training were used for comparison purposes. The

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[8]Additional funding has been obtained for analysis of some of the remaining data, with a report expected by September 2007.

maximum possible score for all three events is 300. This score was used for the "overall" APFT score.

4.3.3 Musculoskeletal Injury Profiles

As a second measure of physical performance, we decided to measure musculoskeletal injuries in terms of "profiles". Musculoskeletal injury profiles are limited duty assignments that restrict a Soldiers' physical performance in order to allow for healing of an existing injury, such as a sprain or strain. Musculoskeletal profile data were recorded, tracked, and supplied by company command staff. These data were recorded in the number of new profiles per Soldier, as well as the total number of days on profile. As defined for this study, "new" profiles refer to musculoskeletal injuries that have occurred for the first time during 68W AIT and for which a Soldier sought medical care.

4.4 Data Analysis

The Statistical Package for Social Sciences (SPSS[9] for Windows, Rel. 12.0.0. 2003) was used for all data analysis. Analysis included basic descriptive data of the population and their test scores. Pearson correlation coefficients (Levin, 1977) were used to examine the relationships between SoAD/HD and IM screening scores, SoAD/HD and performance measures (GPA, APFT, and musculoskeletal profiles), and IM screening scores and performance measures (GPA, APFT, and musculoskeletal profiles). A step-wise (backwards) regression (Hair, Anderson, Tatham, & Black, 1998) was used to examine the IM as a screening tool to predict SoAD/HD. A step-wise (backwards) regression was also used to examine the ability of the SoAD/HD and IM screening scores to predict 68W AIT performance (GPA, APFT, and musculoskeletal profiles). A p-value of 0.05 was used to determine significance levels. However, since the IM is a new technology and only task average (TA) has been reported in the open literature, all scoring categories were reported and those findings that were deemed "marginal" ($p = 0.05$ to 0.06) were also reported (table 3 contains a description of each score).

5. Results

5.1 Descriptive Statistics

Table 4 describes the group of 68W Soldiers who participated in the IM evaluation (n = 122).

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[9]SPSS is a registered trademark of SPSS, Inc., Chicago, IL.

Table 4. Demographics*.

Marital Status	No.	Percent	Military Component	No.	Percent
Married	11	9.0	Active Army	81	66.4
Divorced	2	1.6	Army Reserve	17	13.9
Living with Partner	4	3.3	Army National Guard	24	19.7
Single	103	84.4	Total	122	100
Separated	2	1.6	**Education**		
Total	122	100	GED	3	2.5
Gender			High School Diploma	80	65.6
Male	67	54.9	Some college, no degree	29	23.8
Female	55	45.1	Associate's degree	3	2.5
Total	122	100	Bachelor's degree	7	5.7
Ethnicity/Race			Total	122	100
Hispanic	13	10.7	**High School (HS) Science Grades**		
Caucasian	85	69.7	Above Average	62	50.8
Asian	7	5.7	Average	47	38.5
African American	9	7.4	Below Average	12	9.8
Native American	1	0.8	Failing	0	0
Other	1	0.8	Did Not Report	1	0.8
Did not report race	6	4.9	Total	122	100
Total	122	100	**HS Final Grades**		
Age Group			Above Average	60	49.2
17-19	71	58.2	Average	51	41.8
20-24	23	18.9	Below Average	9	7.4
25-29	8	6.6	Failing	1	0.8
>=30	3	2.5	Did Not Report	1	0.8
Did not report age	17	13.9	Total	122	100
Total	122	100	*Totals (%) not reaching exactly 100 are attributable to rounding.		

5.1.1 Barkley and Murphy's Attention Deficit and Hyperactivity (AD/HD) Scale

Scores on Barkley and Murphy's AD/HD scale that are above the adult norm indicate SoAD/HD but not a diagnosis of AD/HD. Those who score above the norm may benefit from further self-evaluation or referral to a medical professional for additional screening (table 5).

5.1.2 IM Scores and Definitions of Subscores

TA is the subscore most commonly assessed and reported in existing IM research. The norms below have been supplied by IM according to their Certified Provider Basic Training Course and Resource Binder (2004) (table 6). These results are not limited to the short, two-part test (clapping with and without auditory feedback) but are a compilation of both the short, two-part test and a longer multiple construct assessment. However, representatives from the company that created and maintain the IM recommend using these TAs for comparison purposes with other populations since no other comparison scores are available. The TA results for the 68W trainees are shown in table 7. At this time, IM does not publish percentages achieved by the population, such as the percentage achieving superior, exceptional, etc.

Table 5. SoAD/HD descriptive statistics*.

Overall SoAD/HD Scores	No.	Percent
Below Adult Norm	77	63.1
Above Adult Norm	43	35.2
Missing	2	1.6
Total	122	100
Inattention Sub score		
Below Adult Norm	108	88.5
Above Adult Norm	12	9.8
Missing	2	1.6
Total	122	100
Hyperactive-Impulsive Sub score		
Below Adult Norm	105	86.1
Above Adult Norm	15	12.3
Missing	2	1.6
Total	122	100
ODD Sub score		
Below Adult Norm	102	82.8
Above Adult Norm	18	15.6
Missing	2	1.6
Total	122	100

*Totals (%) not reaching exactly 100 are attributable to rounding.

Table 6. Task average scores supplied by interactive metronome.

Task Average Levels	Score (in ms)
Superior	Under 22
Exceptional	22 to 29
Above Average	30 to 40
Average	41 to 69
Below Average	70 to 146
Severe Deficiency	147 to 199

Table 7. Task averages of 68W trainees.

Without Auditory Cues	No.	Percent
Superior	2	1.6
Exceptional	9	7.4
Above Average	22	18
Average	49	40.2
Below Average	30	24.6
Severe Deficiency	10	8.2
With Auditory Cues		
Superior	2	1.6
Exceptional	8	6.6
Above Average	14	11.5
Average	32	26.2
Below Average	50	41
Severe Deficiency	16	13.1

5.1.3 GPA

The GPA mean was 85.77% ($\pm$5.41 standard deviation (SD); range 64 to 97). For men, it was 86.25% ($\pm$4.74 SD; range 76 to 97) and for women 85.18% ($\pm$6.11 SD; range 64 to 97).

5.1.4 APFT Scores

APFT scores are shown in tables 8 through ll.

Table 8. Overall APFT scores for men and women (maximum = 300, maximum per event = 100).

Men	Mean	SD	Range
Ages 17-19	229.03	29.23	167-277
20-24	231.62	25.95	196-285
25-29	226.60	8.76	213-237
>=30	192	8.48	186-198
Women	**Mean**	**SD**	**Range**
Ages 17-19	232.38	38.02	141-295
20-24	238.44	33.68	175-281
25-29	252.67	30.00	223-283
>=30	245.00	n = 1	245-245

Table 9. Push-up scores for men and women (raw score = number of push-ups in 2 minutes).

Men	Mean	SD	Range
Ages 17-19	51.60	8.04	25-66
20-24	52.15	7.52	42-64
25-29	47.80	3.83	43-52
>=30	36.50	6.36	32-41
Women	**Mean**	**SD**	**Range**
Ages 17-19	34.32	11.28	15-71
20-24	34.56	13.90	20-62
25-29	33.67	13.86	22-49
>=30	40.00	n = 1	40-40

Table 10. Sit-up scores for men and women (raw score = number of sit-ups in 2 minutes).

Men	Mean	SD	Range
Ages 17-19	67.80	8.94	52-87
20-24	67.23	7.54	56-78
25-29	64.60	9.09	57-79
>=30	49.50	3.53	47-52
Women	**Mean**	**SD**	**Range**
Ages 17-19	63.26	9.86	39-84
20-24	66.78	9.37	52-80
25-29	66.33	6.02	60-72
>=30	59.00	n = 1	59-59

Table 11. Running times for men and women (raw score = 2-mile run time).

Men	Mean	SD	Range
Ages 17-19	14.67	1.52	12.10-19.37
20-24	14.67	1.04	12.55-19.37
25-29	15.11	.745	14.26-16.20
>=30	17.23	.134	17.14-17.33
Women	**Mean**	**SD**	**Range**
Ages 17-19	17.65	2.32	13.59-27.10
20-24	17.71	1.11	15.46-19.42
25-29	15.86	2.16	13.36-17.18
>=30	17.49	n = 1	17.49-17.49

5.1.5 Profile Data

The mean number of new musculoskeletal profiles per person was 1.85 ±1.54, range: 1 to 7. The mean number of days on profile, per profile, was 21.94 ±25.00, range: 3 to 125.

5.2   Correlations

Only significant findings are included in the correlation data.[10]

5.2.1 Barkley's SoAD/HD with IM, GPA, APFT, and Injury Data

Soldiers with higher self-rated SoAD/HD, both overall and in the area of inattention, attained IM scores that fell into the category of very late average (VLA) on the IM clapping task without auditory cues ($p < 0.05$, table 12).

Table 12. Correlations between SoAD/HD and IM clapping task without auditory
cues (without C).

Overall Score	r	p value	DF
Very Late Average	0.188	0.039	121
Inattention	**r**	**p value**	**DF**
Very Late Average	0.327	0.000	121

Only one of the four categories of SoAD/HD was correlated with AIT performance. Soldiers with higher self-rated SoAD/HD in the area of ODD had lower GPAs ($p < 0.05$, table 13)[11]. No correlations were found between SoAD/HD and physical performance, either on the APFT or for sustaining musculoskeletal injuries.

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[10]No data are presented for the relationships between GPA and APFT since this was not relevant to the hypotheses.

[11]Consequential analysis of data with 579 AIT Soldiers (in a separate study) revealed correlations between GPA and SoAD/HD overall (r = -0.11, p = 0.008), subtype inattentive (r = -0.13, p = 0.002), and ODD (r = 0.10, p = 0.016) (Rice et al., unpublished data).

Table 13. Correlations between SoAD/HD and final GPA.

SoAD/HD	r	p value	DF
ODD	-0.199	0.029	119

5.2.2 IM with GPA and Physical Performance (APFT and Musculoskeletal Profiles and Profile Days)

No significant correlations were found between Soldiers IM screening results and final GPA. A number of correlations were found between IM scores and physical performance on the APFT (table 14; see table 3 for acronyms and explanations of evaluative measures). For the IM without C, Soldiers with higher very early (VE) averages performed fewer push-ups. Those with high TAs, high variability, higher VE and VLAs performed fewer sit-ups. There was a positive correlation between highest IAR and sit-ups, as well as between SRO% and sit-ups. That is, those with higher IAR and SRO% scores also achieved a higher numbers of sit-ups.

Table 14. Correlations between scores on the IM clapping task without auditory cues (without C) and APFT performance (n = 118).[12]

Push-ups	r	p value
Very Early Average	-1.84	0.46
Sit-ups		
Task Average	-0.187	0.04
Variability	-0.185	0.045
Highest IAR	0.244	0.008
Very Early Average	-0.206	0.025
SRO %	0.193	0.036
Very Late Average	-0.217	0.018

The IM with auditory cues (with C) scores showed that Soldiers with higher TAs and VE averages performed fewer push-ups, while a higher number of bursts, highest IAR and SRO% were associated with performing a greater number of push-ups (table 15). A higher TA was also associated with performance of fewer sit-ups, and a higher SRO% was associated with performing a greater number of sit-ups (table 15).

No significant findings were seen between the IM clapping task without C and the number of profiles or total profiles days experienced by Soldiers during AIT. Soldiers with a higher SRO% score for the IM clapping task with C spent fewer days on profile (table 16).

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[12]All rows in tables with IM data are sequenced in accordance with the description of IM scores seen in table 16.

Table 15. Correlations between scores on the IM clapping task with
auditory cues (with C) and APFT performance (n = 118).

Push-ups	r	p-value
Task Average	-0.259	0.005
No. of Bursts	0.189	0.040
Highest IAR	0.246	0.007
Very Early Average	-0.194	0.036
SRO %	0.297	0.001
Sit-ups	**r**	**p-value**
Task Average	-0.233	0.011
SRO %	0.188	0.041
Run Time	**r**	**p-value**
Highest IAR	-0.222	0.016
SRO%	-0.217	0.018
Overall Score	**r**	**p-value**
SRO%	0.211	0.022

Table 16. Correlations between scores on the IM clapping task with auditory cues (with C)
and total profile days during AIT.

Total Days in Profile	r	p-value	DF
SRO%	-0.183	0.044	121

5.3   Regression Analysis

5.3.1 IM Prediction of SoAD/HD

Two IM sub scores on the clapping task without C predicted 13.3% of the variance ($R^2 = 0.133$) on SoAD/HD Inattention: VLA ($\beta = 0.34$, t(109) = 3.94, $p < .01$) and Number of Bursts ($\beta = 0.16$, t(109) = 1.89, $p > .05$). With only the sub-score that reached statistical significance, this means that for every one point increase in VLA, there was a 0.02 increase in SoAD/HD Inattention score.

VLA on the IM without C was also predictive of overall SoAD/HD, accounting for 3.6% of the variance ($R^2 = 0.036$; $\beta = 0.188$, t(109) = 2.085, $p < .05$).   This means that for every one point increase in VLA, the increase in overall SoAD/HD is 0.02.

None of the IM with C scores was a significant predictor of SoAD/HD scores.

5.3.2 IM Prediction of GPA

The IM scores on the clapping task without C were not predictive of GPA. However, IM scores with Cs were predictive of GPA, with four sub-score items accounting for 10.7% of the variance ($R^2 = .107$, table 17).

Table 17. Regression analysis using IM scores on the clapping task with auditory cues (with C) to predict GPA.

Predictive Variable	Un-standardized coefficients		Standardized coefficients	t	sig
	B	Standard Error	Beta		
Constant	92.543	1.933		47.874	0.000
Task Average	-.039	0.013	-0.399	-3.047	0.003
Highest IAR	-.934	0.309	-0.344	-3.024	0.003
Late Average	-.083	0.033	-0.252	-2.491	0.014
Very Late Average	0.013	0.007	0.225	1.976	0.051

5.3.3 IM Prediction of APFT

IM sub-scores on both the clapping task without C and the clapping task with Cs were predictive of components of the APFT. On the clapping task without C, two IM sub-scores, average of early and average of late beats, were negative predictors of the number of push-ups and number of sit-ups achieved, accounting for 6.3% and 10.1% of the variance, respectively (table 18).

Table 18. Regression analysis using IM scores on the clapping task without auditory cues (without C) to predict APFT components.

Predictive Variable	Un-standardized coefficients		Standardized coefficients	t	sig
	B	Standard Error	Beta		
Push-ups					
Constant	59.578	5.588		10.662	0.000
Early Average	-0.238	0.098	-0.225	-2.424	0.017
Late Average	-0.177	0.094	-0.175	-1.883	0.06*
Sit-ups					
Constant	78.915	4.064		19.420	0.000
Early Average	-0.188	0.071	-0.239	-2.634	0.010
Late Average	-0.206	0.068	-0.273	-3.005	0.003

*marginal

SRO% on the clapping task with C was found to be a positive predictor of number of push-ups, accounting for 8.8% of the variance. TA, VE average, and LA were negative predictors, while variability was a positive predictor for sit-ups, accounting for 12.6% of the variance. Early average and SRO% were both negative predictors of run time, accounting for 7.3% of the variance. SRO% was a positive predictor of overall APFT score, accounting for 4.5% of the variance (table 19).

5.3.4 IM and Profile Data

Four sub-scale items on the IM clapping task with C predicted the number of profiles per person, accounting for 9.9% of the variance ($R^2 = 0.099$); however, only three reached statistical significance. All four were negative predictors of profile days: TA (ß = -0.229, t(111) = -1.7, $p > .05$), SRO% (ß = -0.571, t(111) = -3.028, $p < .01$), early average (ß = -0.342, t(111) = -2.350, $p < .05$),

and LA (ß = -0.266, t(111) = -2.775, p < .01). For every one-point increase in early average, there is a decrease of 0.02 total number of profiles during AIT. The results are similar for SRO% (-0.04) and LA (-0.02).

Table 19. Regression analysis using IM scores on the clapping task with auditory feedback (CTAF) to predict APFT components.

Predictive Variable	Un-standardized coefficients		Standardized coefficients	t	sig
	B	Standard Error	Beta		
Push-ups					
Constant	40.111	1.787		22.446	0.000
SRO %	0.290	0.087	0.297	3.347	0.001
Sit-ups					
Constant	73.339	2.720		26.967	0.000
Task Average	-0.084	0.025	-0.466	-3.329	0.001
Variability	0.195	0.073	0.524	2.656	0.009
Very Early Average	-0.054	0.027	-0.303	-1.973	0.051*
Late Average	-0.121	0.056	-0.201	-2.163	0.033
Run Time					
Constant	18.661	1.257		14.848	0.000
Early Average	-0.034	0.019	-0.243	-1.805	0.074
SRO %	-0.065	0.022	-0.398	-2.960	0.004
APFT Score					
Constant	225.068	4.670		48.194	0.000
SRO %	0.528	0.227	0.211	2.327	0.022

SRO% with C was correlated with the total number of profile days (-0.18, p = 0.04). Two scores on the IM clapping task with C were negatively predictive of total days on profile, accounting for 5.7% of the variance (R^2 = 0.057): SRO% (ß = -0.189, t(111) = -2.118, p < .05) and LA (ß = -0.153, t(111) = -1.72, p > .01).

5.3.5 IM and SoAD/HD Scores to Predict GPA

When combining IM and SoAD/HD to predict performance, only ODD was a significant predictor, accounting for only about 4% of the variance (R^2 = 0.037, ß = -0.217, t(114) = -2.091, p = .039).

5.3.6 IM and SoAD/HD Scores to Predict APFT

Table 20 shows the results for the combination of IM scores and SoAD/HD that were predictive of the APFT scores. ODD and LA with Cs were predictive of push-ups (R^2 = 0.073) and sit-ups (R^2 = 0.096). The overall SoAD/HD score was predictive of run time (R^2 = 0.074), and no predictors were significant for predicting the overall APFT score.

Table 20. Regression analysis using IM scores on the clapping task with auditory feedback (CTAF) and SoAD/HD to predict APFT components.

Predictive Variable	Un-standardized coefficients		Standardized coefficients	t	sig
	B	Standard Error	Beta		
Push-ups					
Constant	76.097	4.019		22.166	0.000
ODD	- 0.880	0.349	-0.232	3.347	0.013
Late Average	0.282	0.141	0.183	1.997	0.048
Sit-ups					
Constant	79.863	3.712		21.515	0.000
ODD	-0.902	0.336	-0.241	-2.689	0.008
Late Average	0.425	0.213	0.179	2.000	0.048
Run Time					
Constant	83.586	4.516		18.508	0.000
Overall SoAD/HD	-0.537	0.178	-0.272	-3.015	0.003
APFT Score					
No Significant Predictors					

5.3.7 IM and SoAD/HD Scores to Predict Profiles

Table 21 displays the combination of IM and SoAD/HD score predictions regarding musculo-skeletal profiles. Both the number of days per profile and the total profile days (all days on profile, including multiple profiles) were predicted by the SRO% with Cs. When predicting number of days per profile, the prediction model accounted for 5.5%% of the variance ($R^2 = 0.052$) and when predicting total profile days, the prediction model accounted for approximately 5% of the variance ($R^2 = 0.047$).

Table 21. Regression analysis using IM scores on the clapping task with auditory feedback (CTAF) and SoAD/HD to predict profile components.

Predictive Variable	Un-standardized coefficients		Standardized coefficients	t	sig
	B	Standard Error	Beta		
Days per profile					
Constant	4.458	0.922		4.834	0.000
SRO%	- 0.109	0.044	-0.227	-2.490	0.014
Total profile days					
Constant	7.011	1.539		4.557	0.000
SRO%	-0.173	0.073	-0.216	-2.362	0.020
Number of profiles per person					
No Significant Predictors					

6.   Discussion

As seen in the results section, Soldiers participating in this study were primarily single, Caucasian, between the ages of 17 and 19, and active duty Army. The majority reported average or above average science and overall final grades in high school.

The results of this study support the idea that the SoAD/HD can interfere with academic performance during AIT. They also support the premise that timing and rhythm play an important role in both cognitive and motor task performance.

6.1   SoAD/HD

Most of the participating Soldiers scored below the adult norm on SoAD/HD, but just over a third scored above the adult norm (this percentage was artificially created to match the 30% found in the larger scale study; see section 4.0). A greater percentage of Soldiers self-reported symptoms of AD/HD were above adult norms on ODD (15.6%), compared with hyperactive-impulsive (12.3%) and inattentive (9.8%) types.

6.1.1 SoAD/HD and GPA

Of four potential scores associated with SoAD/HD, only ODD was found to be associated with GPA. Soldiers with high symptoms of ODD had lower GPAs. In this case of self-report, the individuals do not necessarily have the clinical disorder of ODD, but they rated themselves as having symptoms commensurate with the following: tending to be negative, hostile, or defiant and to have exhibited a pattern of behavior lasting at least 6 months during which they have at least four of the following (DSM-IV text revision, 2000):

1. often loses temper,

2. often argues with adults,

3. often actively defies or refuses to comply with adults' requests or rules,

4. often deliberately annoys people,

5. often blames others for their own mistakes or misbehavior,

6. is often touchy or easily annoyed by others,

7. is often angry and resentful,

8. is often spiteful and vindictive.

Typically, a person with ODD demonstrates impairment in his or her social, academic, or occu-pational functioning, caused by behavior. In this case, those who rated themselves high in terms

of ODD had lower GPA. That is, those who rated themselves as being less cooperative had lower GPAs.

Prevalence rates for ODD are estimated to be between 6% and 10% in general parental surveys (non-referred, nonclinical) and less when information is obtained from parents and teachers (Tynan, 2006). Our rates were higher than these (15.6%), but no data were available for self-assessment prevalence rates among young adults. After adolescence, rates are nearly equal in men and women.

ODD is not the same as a conduct disorder (CD), nor is the presence of ODD during childhood necessarily a precursor for development of a CD (Biederman et al., 1996). Comorbidity of ODD with AD/HD occurs in 50% to 65% of affected children (Tynan, 2006).

Barkley and Murphy (1998) found that students with AD/HD not only have lower class rankings and GPAs, but they are also suspended more often. However, they did not differentiate between types of SoAD/HD and ODD in that study. Other studies have found that executive functioning skills deficits are found among AD/HD children, but they are independent of comorbidity with ODD (Barkley, Edwards, Lanera, Fletcher, & Metevia, 2001; Klorman et al., 1999) or reading disorders (Klorman et al., 1999)[13]. Barkley's work extended the findings to adolescents to age 19 (Barkely et al., 2001). Yet this issue is not without debate, since other researchers have found cognitive skill deficits among children with ODD in executive functional skills as well as emotion regulation, language processing, and social information processing skills (Greene, Biederman, Zerwas, Monuteaux, Goring, & Faraone, 2002a). Tynan (2006) reports high rates of comorbidity between ODD, learning disorders, and academic difficulties.

Not all experts assume that those with SoAD/HD will perform poorly in academic settings. Greene and his colleagues (Greene, Ablon, & Goring, 2002b; Greene & Ablon, 2003) suggest using a teaching model for children with ODD, which incrementally progresses, thus reducing demands for flexibility and frustration tolerance during the acquisition of new cognitive skills. Hallowell and Ratey (2006) believe that students with AD/HD can succeed, given that teaching methods, self-monitoring, and organizational structure are grounded in a system that augments strengths. They further teach that AD/HD is not necessarily a disorder (only becoming a disorder when it impairs a person's life) but a trait, and that there are distinctive advantageous characteristics of those with AD/HD, such as originality, creativity, persistence, and resilience.

6.1.2 SoAD/HD and APFT

No relationships were found between scores associated with SoAD/HD (four types) and physical performance (four scores) during 68W AIT. This differs from the open literature in which children

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[13]Some of the executive skill tests used were the Wisconsin Card-Sorting Test and Tower of Hanoi (Klorman et al., 1999) and Continuous Performance Test (CPT) inattention, working memory and CPT inhibition (Barkley et al., 2001). Differences in temporal discounting and time reproduction between those with AD/HD and without AD/HD were also not a function ODD (Barkley et al., 2001).

with AD/HD also have motor coordination difficulties (Kadejso & Gillberg, 1998; Pick, Pitcher, & Hay, 1999). The difference in these findings may be attributable to the ages of the test subjects (young adults as opposed to children), the small sample population, or the level severity of AD/HD symptomatology found in studies with children (more severe symptoms equating with more coordination difficulties). The latter explanation could also be the result of our study only examining self-reported symptoms of AD/HD, rather than examining characteristics of those with a clinical diagnosis.

In addition to not identifying relationships between SoAD/HD and physical performance on the APFT, no relationships were found between SoAD/HD and the number of new profiles or total days on profile because of musculoskeletal injury.

6.1.3 SoAD/HD and IM Scores

Relationships were found between the SoAD/HD and scores on the IM. However, of 72 possible correlations, only two were significant for correlations and three measures were significant on regressions. Although this is less than 5% and could be attributable to chance, these correlations do fit within a pattern. The VLA on the clapping task without C was significantly associated with SoAD/HD, in both overall and inattentive categories, with the use of correlations and regression models. Reports in the open literature on the IM use the measure of TA for their statistical analysis (Libkuman, Otani, & Steger, 2002; Mulder, 2002; Shaffer et al., 2001; Toplak & Tannock, 2005) rather than other scores. Scores such as VLA are used to assist patients or clients in understanding their responses and working to improve their TAs. For example, an individual with high scores in the very late category would know that s/he should accelerate responses in order to attain a lower, more desirable TA.

There are several possible reasons why TA did not appear sufficiently sensitive to be associated with SoAD/HD. One is that this study involved using the IM as a screening tool with self-reported symptoms by young adults. Examining IM as a screening tool takes this research project into uncharted territory. In addition, neither self-reported symptoms of AD/HD nor young adults have previously been investigated with the IM. Although it is unknown whether those who reported symptoms have AD/HD (since they were not required to report prior clinical diagnosis), it is not known whether young adults with SoAD/HD score differently than others using TA as a measure. It may be that adults with SoAD/HD, especially those with inattentive (or overall) symptoms, react more slowly than those without SoAD/HD. That is, young adults with inattentive SoAD/HD may be hypo-anticipatory in their reactions and may first hear the beat before they initiate their reactions, rather than establishing their own sequential rhythm to match the beat. VLA may be a better measure for identifying young adults with SoAD/HD or with specific patterns of AD/HD symptoms.

Although this study did not investigate IM training and SoAD/HD, it has been reported that IM training improves attention, motor control, language processing, reading, and regulation of aggression among boys with AD/HD (Shaffer et al., 2001). Doctors Hallowell and Ratey, who

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specialize in the evaluation and treatment of AD/HD among children and adults, suggest cerebellar training (including the IM, Dores, and the Brain Gym[14]) as possible complementary treatment for individuals with AD/HD (Hallowel & Ratey, 2006).

6.2   IM

TA levels for initial screenings for young adults are not currently available. Additionally, it is routine for new IM users to perform better without auditory feedback, as seen among the 68W trainees.

6.2.1 IM and GPA

Although none of the 18 IM measures were correlated with GPA, four scores with auditory feedback were predictive of GPA: TA, LA, and VLA were negatively predictive and IAR scores were positively predictive of GPA (4 of 18 or 22.22% is greater than the 5% expected by chance). A higher IM TA indicates poorer performance; therefore, a negative prediction (higher TA predicting a lower GPA) is reasonable. For every one point increase in TA, there was a 0.04 decrease in GPA. Likewise, higher LA and VLA scores predicting a lower GPA are understandable. VLA did not reach statistical significance, however. Interestingly, VLA was the only measure associated with SoAD/HD, although without auditory feedback.

The higher IAR predicting a lower GPA is less easily understood. In an effort to further investigate this, as well as explain the direction of the IAR prediction (higher IAR predicted lower GPA), each variable was run separately to determine if it predicted GPA, and descriptive statistics were examined. None of the measures alone were predictive of GPA (TA: ß = -0.006, t(117) = -.717, $p > .05$; LA: ß = -0.039, t(117) = -1.313, $p > .05$; IAR: ß = -0.365, t(117) = -1.48, $p > .05$). In addition, the Soldier who attained the lowest GPA (64) also achieved one of the highest SRO trigger taps IAR (7), which skewed the results.

Since this is the first study examining the relationships between IM scores and GPA, it may be that TA and LA are more sensitive measures for associations with GPA. Even with research using the IM as a training tool, GPA has not been used as an outcome measure. Instead, grade equivalent achievement scores have been used. For example, IM training has produced significant improvements of 7% to 20% in reading and math achievement grade equivalency scores among elementary school and high school children, compared with control groups (Taub & McGrew, 2005).

6.2.2 IM and APFT

Soldiers' IM scores were related to their physical performance, as measured by the scores on their first APFT taken during AIT. Seventeen of 72 possible correlations showed a relationship

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[14]The Dore Programme is based on the text, Dyslexia: The Miracle Cure by Wynford Dore. Although originally developed for use with people who have dyslexia, it is also used (with reported success) for persons with attention deficit and hyperactivity disorder, dyspraxia, and Asperger's syndrome. Brain Gym is a program of physical movements said to enhance learning and performance through developing the brain's neural pathways through movement. Both the Dores program and Brain Gym are purported to improve concentration, memory, reading, writing, organizing, and listening, as well as other performance measures.

(23.61%) and 12 of 72 (16.67%) measures were predictive with the use of regression analysis, both of which are greater than the 5% which might be expected by chance. Both screening tests, with and without auditory cues, were related to push-ups and sit-ups performed in the requisite 2 minutes.

For *push-ups*, Soldiers with a high VE average without Cs performed fewer push-ups (correlation), while both higher early and LAs predicted fewer push-ups (without auditory feedback). These results show that Soldiers who either anticipated the beat and clapped before the actual beat (hyper-anticipatory) or responded more slowly than expected (hypo-anticipatory) performed fewer push-ups. These Soldiers had a difficult time matching the reference tone, even without interfering auditory cues. This difficulty in synchronizing the auditory input and motor output and matching a set rhythm would seem to indicate an underlying difficulty with sensorimotor rhythmicity that influences more complex motor behavior, such as the ability to do push-ups. When auditory feedback was added, a higher VE average remained and a higher TA was added in an association with fewer push-ups. In addition, with auditory feedback (distraction), a higher number of bursts IAR and SRO% were associated with a higher number of push-ups, and a higher SRO% was predictive of the number of push-ups achieved. That is, when auditory distractions were added, a stronger set of associations resulted, including TA. The IM scores predicting push-ups without auditory distractions were early and late scores with an R^2 of 6.3, but with auditory cues, SRO% became more predictive with an R^2 of 8.8. This demonstrates that although IM scores are associated with and are predictive of the number of push-ups that Soldiers achieve, adding auditory distractions strengthens the associations and predictions. It also demonstrates that TA is not a sensitive measure for push-ups in this population, unless auditory distractions are present. It would appear that Soldiers anticipated the beat even more with auditory distraction, thus increasing their VE score and negatively impacting overall TA. This supports the idea that for those individuals who anticipated the beat, their underlying sensorimotor rhythmicity is not as well developed as it could be to support the more complex timed physical task. It also demonstrates that without the additional stress of auditory distraction, TA is not of sufficient sensitivity to identify those individuals with potential difficulties.

Fewer *sit-ups* were associated with IM scores without auditory cues, as indicated by higher TA, variability, VE and VLAs on clapping without auditory feedback, while more sit-ups were associated with higher bursts, IAR and SRO%. High early and LAs without auditory feedback were predictive of the number of sit-ups completed in 2 minutes. Once again, Soldiers who anticipated the beat and clapped (tapping the indicator) early and those who were slower than expected (tapping the indicator late) performed fewer sit-ups. In this case, a higher variability in responses was also associated with fewer sit-ups. Matching the beat more frequently (bursts, IAR and SRO%) was associated with performing more sit-ups. As with push-ups, these findings seem to indicate that Soldiers who demonstrate hyper-anticipatory and hypo-anticipatory responses did not perform as well in a timed, complex physical assessment. In this case (sit-ups), a higher TA and response variability were also of sufficient sensitivity to be associated with poorer perform-

ance. When auditory sounds were added, TA remained associated with fewer sit-ups and higher SRO% remained associated a higher number of sit-ups. Adding auditory distractions increased the number of predictors, adding TA and VE average. Once again, this appears to demonstrate that TA is not a sensitive measure unless auditory distractions are added to the task and that stronger predictions result with auditory distractions (R^2 changing from 10.1 to 12.6). It also supports the concept that a sense of sensorimotor rhythmicity is essential for complex physical tasks, such as sit-ups[15].

IM test scores without auditory feedback were not associated with *run time* or *overall APFT* performance. However, when auditory feedbacks (distractions) were added, early average and SRO% were predictive of run time and SRO% was predictive of the overall APFT score. Again, this seems to indicate that the addition of distracting sounds makes the IM task even more difficult for those with underlying timing and rhythmicity difficulties. In turn, the addition of distracting sounds creates a more sensitive set of IM measures to predict a Soldier's ability to perform physical tasks. However, TA is not sufficiently sensitive, even with the addition of auditory distractions, to predict run time or overall APFT achievement.

These data appear to support the supposition that there is a relationship between motor performance (as indicated by APFT scores) with timing and rhythmicity (as measured by the IM). IM training has been shown to improve motor control among AD/HD children (Shaffer et al., 2001) and coordination and visual motor control among special education children (Stemmer, 1997). IM training also improves golf ball placement accuracy among experienced golfers (Libkuman, Otani, & Steger, 2002). Assessments with the IM have not been compared with other physical or perceptual motor-based tasks of Soldiers, such as weapon firing or obstacle course performance.

6.2.3 IM and Profile Data

None of the nine IM measures without auditory feedback were correlated with or predictive of number of profiles or total number of profile days. When auditory distractions were added, a higher TA, SRO%, early and LAs were predictive of fewer profiles per Solider. These predictions do not make intuitive sense, except in the case of the SRO%. These findings may be the result of few Soldiers having had more than one injury (only 15% had three or more profiles; table 22). Only one profile per injury was counted, that is, if a Soldier received a 2-week profile for an injury and then a subsequent profile for another length of time for the same injury, only one profile was documented. Since there were no correlations of 18 potential correlations, the regression findings for the same data may be spurious.

SRO% was both correlated with and predictive of total profile days (LA was also predictive of total profile days). Soldiers with higher SRO% scores spent fewer days on limited duty profile because

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[15]Although there may be alternate definitions, a "complex" task in this report is a task that involves multiple facets, such as multiple muscle groups and multi-part movements. This is opposed to a simple motor task such as single finger tapping.

of a musculoskeletal injury. That is, Soldiers whose IM performance showed a greater percentage of their evaluated time within ±15 ms of the target beat experienced fewer limited duty days.

Table 22. Number of profiles per Soldier, along with percentages.

Number of Profiles	Frequency	Percent of those with at least one profile	Percent of total population
1	98	16.9	61.5
2	38	6.5	23.8
3	10	1.7	6.3
4	7	1.2	4.4
5	4	0.7	2.5
6	2	0.3	1.3
7	1	0.2	0.6
Total	160	27.5	100

Although only one of 18 possible correlations (5.56%) and two of 18 possible regressions (11.11%) were significant (slightly greater than what could be expected by chance), the findings seem to fit with the pattern of relationships seen in this study between IM and APFT scores. Together with the relationships demonstrated between the IM and APFT scores, this may indicate that a greater sense of timing and rhythm enables an individual to perform motor tasks with greater ease and coordination, and this greater coordination may provide protection from musculoskeletal injuries. There are several possible mechanisms for such a protective effect: (a) individuals with greater timing and rhythm may spend more time in sports activities since the Soldiers may have a greater proclivity to tasks that require more coordination. More exercise creates stronger bones and muscles so the Soldiers may have entered the military more physically fit and less prone to overuse injuries from doing too much, too soon; (b) a second but related potential rationale is that individuals with a lower SRO% score are less coordinated and more prone to injury through their use of inefficient motor movement patterns. This is not the same as having a "personality type" that makes one more prone to injury; instead, it addresses motor planning and sequencing skills.

6.3 IM and SoAD/HD Combined Predictions

6.3.1 GPA

When we are predicting GPA, only ODD was predictive, accounting for a small percent of the variance. ODD was found to be correlated with GPA when SoAD/HD was viewed alone (without being combined with IM scores). This would appear to indicate that ODD is more strongly related with grades than IM timing and rhythm scores.

6.3.2 APFT

Surprisingly, ODD and LA with Cs were predictive of push-ups and sit-ups, and overall SoAD/HD was predictive of run time, while no correlations were found between SoAD/HD and physical performance. Of 16 possible SoAD/HD prediction variables, three were found predictive (19%). Given that the R^2 was relatively low (accounting for between 7% and 10% of the variance) and no correlations were found, these results are questionable and would need to be replicated before generaliza-

tions are made. However, in a separate study, we have found that SoAD/HD was corre-lated with the first APFT scores attained by Soldiers attending 68W training, with both ODD and overall SoAD/HD being negatively correlated with push-ups, sit-ups, and run time ($p < 0.05$, n = 581) (Rice, Butler, & Marra, unpublished data). These two studies would appear to indicate that a relationship between SoAD/HD and APFT performance exists. Only two of 96 IM scores were found to be significantly predictive of APFT scores (2%). This is less than the 5% expected by chance and albeit consistent (LA predicting both push-ups and sit-ups), the findings do not match the findings of TA and SRO% when IM alone was used to predict APFT scores. Therefore, this result appears to be spurious.

6.3.3 Profiles

In the prediction of profiles, the more accurate the Soldier was at keeping his or her tapping response within ±15 ms of the reference tone (SRO%), the fewer profile days per profile and total profile days they had. These findings mirror the findings when IM alone was used to predict profiles and SoAD/HD was correlated with profile data. That is, none of the SoAD/HD scores were correlated with profile data, and several IM measures were correlated with and predicted profile data, including SRO% being negatively associated with profile days. Two of 24 potential IM predictors (8.3%) were predictive and these followed a similar pattern as when IM was viewed alone. As previously noted, these findings suggest that a greater sense of timing and rhythm may provide mechanism of protection from musculoskeletal injuries. Once again, only the task with auditory feedback was predictive.

7. Limitations

Potential limitations of this research include self-selection (using volunteers versus having all students participate), self-reporting, using one group of AIT attendees, and evaluating only the beginning short form of the IM assessment for analysis. Even as it is possible that self-selection resulted in a bias, the fact that more than 90% of the students volunteered for the overall study, from which a random sample was drawn for this study, lends support to the belief that a normal sample was drawn. Although 100% participation can be required for research involving educa-tional effectiveness studies, giving students who have little control over their time and activities the ability to choose whether they wanted to participate potentially offered a greater chance of active, honest participation.

Self-reports of SoAD/HD do not equate with a clinical diagnosis of AD/HD. In this case, we were particularly interested in identifying symptoms that currently exist and may interfere with performance rather than a clinical diagnosis based on a childhood history. This was because of the intended use of research findings, that is, to use the research findings to design training and training interventions to assist students attending 68W AIT. Generalization of these findings to

other populations should be done with caution since this sample, drawn from military combat medic trainees, may not be representative of other populations. This report addresses only those findings on the initial short form assessment of the IM. There is also a long form assessment and a second short form assessment, which is given after the long form assessment.

8.   Conclusions

The purpose of this study was to investigate the relationships between (a) SoAD/HD, (b) results from a new interactive computer technology used to assess neuro-cognitive function in terms of auditory and visual input with psycho-motor timing and rhythm output, and (c) Soldier performance during 68W AIT. Significant relationships were found among the three. In addition, the following conclusions can be drawn from these research findings:

1. Self-reported SoAD/HD scores are associated with final 68W AIT GPA but not with APFT or musculoskeletal injuries.

2. Soldiers with higher self-reported ODD SoAD/HD received lower academic grades during 68W AIT[16].

3. Neuro-cognitive function, as measured by an IM assessment, is associated with self-reported SoAD/HD, GPA, APFT scores and musculoskeletal injury profile days among Soldiers attending 68W AIT.

4. TA may not be the most sensitive IM assessment measure for all situations and circumstances. Others, such as SRO% or VLA may also be useful for screening purposes and may be sensitive to particular issues or difficulties (VLA was associated with SoAD/HD, for example).

5. IM assessment measures with and without auditory feedback appear to be sensitive to different situations and circumstances. For example, IM assessments with auditory feedback appear more sensitive in screening for complex physical performance.

The findings from this study are extremely important to the military and the U.S. Army. SoAD/HD can interfere with learning and retaining information, but feedback to Soldiers with these symptoms can help them discover how they best absorb and remember information. Many individuals with SoAD/HD or even with diagnosed AD/HD have been extremely successful in their lives and careers. Understanding themselves and their symptoms enables them to structure their lives to make the best of their abilities and mitigate negative effects. Thus, Soldiers can begin

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[16]Note earlier footnote in which additional studies have revealed relationships between overall SoAD/HD and GPA and inattentive type SoAD/HD and GPA.

to format their own methods of learning early in their military career, thus enabling them to gain the necessary knowledge for competence in their MOS.

Feedback to instructors about the Soldiers attending their classes, including how they think, function and learn, can guide instructors in organizing their teaching so that students can learn and retain information more effectively. Without this information, a number of bright, creative young men and women will experience frustration and undue difficulty during training, in organizng their time, and reaching the level of achievement within the military that matches their potential.

The IM evaluation appears to offer promise as a training tool for Soldiers identified as being at risk for having difficulties during AIT. Additionally, if this type of "brain training" works to improve Soldiers' ability to focus, concentrate, and learn, it could be of great use in other situations (for example, in other training situations).

In light of the strong relationship with Soldiers' physical performance (APFT) shown in this study and its use by elite athletes, it may be of great benefit for training to improve perceptual-motor Soldiering skills. Possibilities include training to improve weapon firing and motor skills for quick agility to overcome physical obstacles. Such training might improve the biomechanics and techniques used during fitness training and reduce musculoskeletal injuries.

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9. Further Research

The results of this research are far-reaching for the Army Medical Department and the Army as a whole. Potentially, AMEDD will (a) decrease the cost of health care by improving the passing rate in an academically challenging medical MOS experiencing a severe personnel shortage, and (b) improve the quality of health care by increasing AIT trainees' ability to focus their attention and learn the material. For the Army, results will potentially identify whether (a) there is a population of Soldiers who need to be screened from entering the Army or who are potentially good Soldiers in need of an alternate from of education and (b) a new technology can assist Soldiers who are having difficulty passing a challenging AIT program.

The following recommendations are made, in light of findings from this research:

1. There is a need to conduct further assessments of the presence or absence of SoAD/HD among Soldiers, as well as the relationship between SoAD/HD and Soldier performance. These studies should involve a larger and more diverse population (other MOSs) and should include additional assessment techniques for identifying AD/HD.

2. This study investigated only one of three initial IM assessments: a clapping task with and without auditory feedback, given without any training or practice on the IM device. The other two assessments, a long form involving 13 tasks and the same short version used in

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this study but following IM practice with both the short and long form assessments, should also be investigated for their potential use as screening tools.

3. There is sufficient information from this study to warrant investigation into the potential benefit of neuro-cognitive training to Soldier performance. These studies should involve cognitive as well as physical performance during training and post-initial training. One such study is scheduled at Fort Sam Houston among 68W Soldiers attending AIT.

4. Research on the potential mechanisms of action, generalizing of training results, and identifying benefits of IM training for specific populations (healthy and injured) would expand the current literature and make this a more useful tool for therapists selecting interventions for Soldiers.

5. Further research on the IM as a screening tool is necessary to shed light on which measures are most sensitive as correlates or predictors and whether sensitivity differs for alternate conditions or circumstances.

6. Research using the IM as a training tool to improve physical performance appears warranted; this could include

   a. Training before BCT to determine if injuries and/or profile days are reduced.

   b. Training to improve psychomotor performance and agility, such as weapon firing or obstacle course performance.

   c. Training of injured Soldiers to assist with cognitive and psychomotor performance, such as with Soldiers who have experienced traumatic brain injuries or amputations.

In light of the positive findings with this form of "brain training," other devices, training mechanisms, and times for training may warrant investigation.

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Acronyms

ADD   attention deficit disorder

ADHD   attention deficit and hyperactivity disorder

AIT   Advanced Initial Training

AMEDDC&S   U.S. Army Medical Department Center & School

APFT   Army Physical Fitness Test

ASVAB   Armed Services Vocational Aptitude Battery

BCT   basic combat training

CD   conduct disorder

CPT

CTAF   clapping task with auditory feedback

DSM-IV   Diagnostic and Statistical Manual of Mental Disorders 4th Edition

FY   fiscal year

GED   general equivalency diploma

GPA   grade point average

HS   high school

IAR   in a row

IM   Interactive Metronome

LA   late average

MOS   military occupational specialty

ms   milliseconds

ODD   oppositional defiant disorder

SD   standard deviation

SoAD/HD   attention deficit and hyperactivity disorder

SRO%   super right on percent

TA   task average

VE   very early

VLA   very late average

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